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(54) **Atherosclerosis treatment**

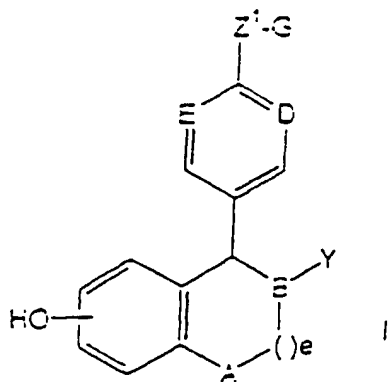
(57) The use of a compound of the formula (I):-

wherein

A is CH₂ or NR in which R is H or C₁-C₆ alkyl;
B, D, E are each CH or N;
Y, Z¹ and G are certain stated substituents:

and

e is 0, 1 or 2; for the manufacture of a medicament
for treating atherosclerosis.

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Description**BACKGROUND OF THE INVENTION**

5 This invention relates to a method of treating atherosclerosis in mammals, including humans, with certain estrogen agonists/antagonists.

Myocardial infarction is the leading cause of death in western countries, accounting annually for more than 500,000 deaths in the United States alone. Coronary artery stenosis and the number of diseased vessels are accepted markers of cardiac morbidity and mortality. The rupture of unstable atherosclerotic plaques contributes to nearly 75% of all myocardial infarctions and strokes. However, angiography does not predict future sites of occlusion and or rupture. Recent studies suggest that 72% of coronary events are not of severe calcified, fibrotic lesions but rather from rupture of mildly stenotic lipid rich plaques, often not visible by angiography (Circulation, 1994; 90:4: 2126-2146). Several recent studies have shown that increased macrophage infiltration is associated with erosion of the extracellular matrix of an atherosclerotic lesion, weakening of the lesion cap and increased vulnerability to rupture (Circulation, 1994;90: 1869-1878.). It has been suggested that uncontrolled monocyte infiltration leads to excessive lipid accumulation and increased extracellular breakdown of the fibrous cap of the atherosclerotic lesion, thus triggering thrombosis. It has also been suggested that an inhibitor of the pro-inflammatory responses, will enhance plaque stability by preventing excessive monocyte infiltration.

Also, Wiseman, et al. *Biochem. Pharm.* 45, No. 9, 1851 (1993) have disclosed the role of lipid peroxidation in cardiovascular injury and the development of atherosclerosis. In addition, Wiseman et al. *Cancer Letters* 66, 61 (1992) have disclosed that droloxifene inhibits lipid peroxidation. Also, U.S. pat. no. 5,047,431 discloses the use of droloxifene for the treatment of hormone dependent mammary tumors and U.S. pat. no. 5,254,594 discloses the use of droloxifene for the relief of bone diseases caused by the deficiency of estrogen. U.S. pat. no. 5,426,123 discloses the lipid lowering effects of droloxifene.

In addition Grainger, et al., *Nature Medicine*, Vol. 1, No. 10 (October 1995) have disclosed tamoxifen suppresses diet-induced formation of lipid lesions in mouse aorta.

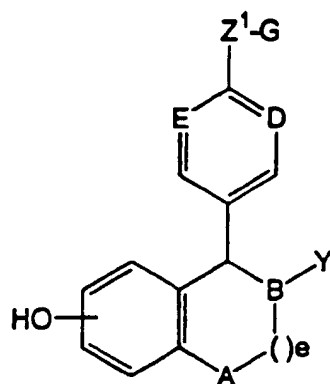
Thus, although there exist a variety of anti-atherosclerotic therapies there is a continuing need and a continuing search in this field of art for alternative therapies for treating atherosclerosis.

SUMMARY OF THE INVENTION

This invention is directed to a method of treating atherosclerosis, independent of lipid lowering, in mammals, including humans, in need of treatment by inhibiting progression of an atherogenic lesion or by stabilizing plaque. Preferably, such lesion progression inhibition or plaque stabilization is achieved by directly inhibiting chemokine expression leading to excessive inflammatory cell recruitment by administering a therapeutically effective amount of a compound of Formula I. Such lesion progression inhibition or plaque stabilization is also achieved by the inhibition of the peroxidation of lipids.

While not wishing to be held to any theory, it is believed the above described effects (inhibiting atherogenic progression and stabilizing plaque) preferably occur through inhibition of the recruitment of inflammatory cells by directly controlling the expression of a gene. This direct control of the expression of a gene is distinct from the inhibition of the peroxidation of lipids (which also occurs) because it involves the direct controlling of chemokines at the DNA level rather than indirectly preventing gene expression by preventing lipid oxidation through the antioxidant properties of these compounds. This is independent of the lipid lowering effects of these compounds.

The compounds of formula I have the formula



Formula I

wherein:

A is selected from CH_2 and NR ;

B, D and E are independently selected from CH and N;

Y is

(a) phenyl, optionally substituted with 1-3 substituents independently selected from R^4 ;

(b) naphthyl, optionally substituted with 1-3 substituents independently selected from R^4 ;

(c) C_3 - C_8 cycloalkyl, optionally substituted with 1-2 substituents independently selected from R^4 ;

(d) C_3 - C_8 cycloalkenyl, optionally substituted with 1-2 substituents independently selected from R^4 ;

(e) a five membered heterocycle containing up to two heteroatoms selected from the group consisting of -O-, - NR^2 - and - $\text{S}(\text{O})_n$ -, optionally substituted with 1-3 substituents independently selected from R^4 ;

(f) a six membered heterocycle containing up to two heteroatoms selected from the group consisting of -O-, - NR^2 - and - $\text{S}(\text{O})_n$ -, optionally substituted with 1-3 substituents independently selected from R^4 ; or

(g) a bicyclic ring system consisting of a five or six membered heterocyclic ring fused to a phenyl ring, said heterocyclic ring containing up to two heteroatoms selected from the group consisting of -O-, - NR^2 - and - $\text{S}(\text{O})_n$ -, optionally substituted with 1-3 substituents independently selected from R^4 ;

Z' is

(a) $-(\text{CH}_2)_p \text{W}(\text{CH}_2)_q-$;

(b) $-\text{O}(\text{CH}_2)_p \text{CR}^5\text{R}^6-$;

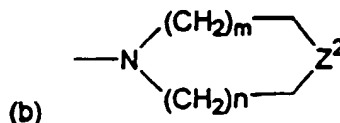
(c) $-\text{O}(\text{CH}_2)_p \text{W}(\text{CH}_2)_q-$;

(d) $-\text{OCHR}^2\text{CHR}^3-$; or

(e) $-\text{SCHR}^2\text{CHR}^3-$;

G is

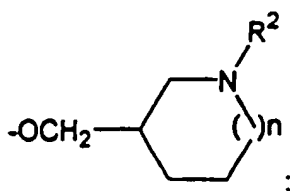
(a) $-\text{NR}^7\text{R}^8$;



wherein n is 0, 1 or 2; m is 1, 2 or 3; Z^2 is -NH-, -O-, -S-, or - CH_2 -; optionally fused on adjacent carbon atoms with one or two phenyl rings and, optionally independently substituted on carbon with one to three substituents and, optionally, independently on nitrogen with a chemically suitable substituent selected from R^4 ; or

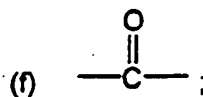
(c) a bicyclic amine containing five to twelve carbon atoms, either bridged or fused and optionally substituted with 1-3 substituents independently selected from R^4 ; or

Z^1 and G in combination may be

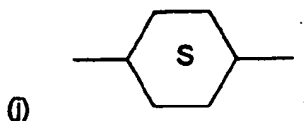


W is

- 15
- 20
- (a) $-CH_2-$;
 - (b) $-CH=CH-$;
 - (c) $-O-$;
 - (d) $-NR^2-$;
 - (e) $-S(O)_n-$;



- 30
- (g) $-CR^2(OH)-$;
 - (h) $-CONR^2-$;
 - (i) $-NR^2CO-$;



or

- (k) $-C\equiv C-$;

40

R is hydrogen or C_1-C_6 alkyl;
 R^2 and R^3 are independently

- 45
- (a) hydrogen; or
 - (b) C_1-C_4 alkyl;

R^4 is

- 50
- 55
- (a) hydrogen;
 - (b) halogen;
 - (c) C_1-C_6 alkyl;
 - (d) C_1-C_4 alkoxy;
 - (e) C_1-C_4 acyloxy;
 - (f) C_1-C_4 alkylthio;
 - (g) C_1-C_4 alkylsulfinyl;
 - (h) C_1-C_4 alkylsulfonyl;
 - (i) hydroxy (C_1-C_4)alkyl;
 - (j) aryl (C_1-C_4)alkyl;
 - (k) $-CO_2H$;

- (l) -CN;
 (m) -CONHOR;
 (n) -SO₂NHR;
 (o) -NH₂;
 (p) C₁-C₄ alkylamino;
 (q) C₁-C₄ dialkylamino;
 (r) -NHSO₂R;
 (s) -NO₂;
 (t) -aryl; or
 (u) -OH;

R⁵ and R⁶ are independently C₁-C₈ alkyl or together form a C₃C₁₀ carbocyclic ring;
 R⁷ and R⁸ are independently

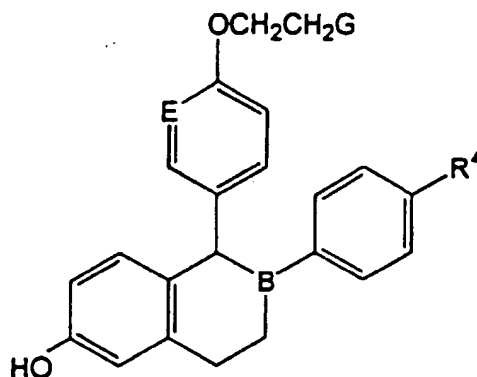
- (a) phenyl;
 (b) a C₃-C₁₀ carbocyclic ring, saturated or unsaturated;
 (c) a C₃-C₁₀ heterocyclic ring containing up to two heteroatoms, selected from -O-, -N- and -S-;
 (d) H;
 (e) C₁-C₆ alkyl; or
 (f) form a 3 to 8 membered nitrogen containing ring with R⁵ or R⁶;

R⁷ and R⁸ in either linear or ring form may optionally be substituted with up to three substituents independently selected from C₁-C₆ alkyl, halogen, alkoxy, hydroxy and carboxy;

- a ring formed by R⁷ and R⁸ may be optionally fused to a phenyl ring;
 e is 0, 1 or 2;
 m is 1, 2 or 3;
 n is 0, or 2;
 p is 0, 1, 2 or 3;
 q is 0, 1, 2 or 3;

and optical and geometric isomers thereof; and nontoxic pharmacologically acceptable acid addition salts, N-oxides, esters and quaternary ammonium salts thereof.

Preferred compounds of the invention for the above methods are of the formula:



wherein G is



R⁴ is H, OH, F, or Cl; and B and E are independently selected from CH and N.

A preferred dosage for the above methods is about 0.0001 to 200 mg/kg/day, preferably 0.001 to 10 mg/kg/day. Especially preferred compounds of the invention for the above methods are:

Cis-6-(4-fluoro-phenyl)-5-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,6,7,8-tetrahydro-naphthalene-2-ol;
 (-)-Cis-6-phenyl-5-[4-(2-pyrrolidin-1-yl-ethoxy)-phenyl]-5,6,7,8-tetrahydronaphthalene-2-ol;
 Cis-6-phenyl-5-[4-(2-pyrrolidin-1-yl-ethoxy)-phenyl]-5,6,7,8-tetrahydronaphthalene-2-ol;
 Cis-1-[6'-pyrrolidinoethoxy-3'-pyridyl]-2-phenyl-6-hydroxy-1,2,3,4-tetrahydronaphthalene;
 1-(4'-Pyrrolidinoethoxyphenyl)-2-(4"-fluorophenyl)-6-hydroxy-1,2,3,4-tetrahydroisoquinoline;
 Cis-6-(4-hydroxyphenyl)-5-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,6,7,8-tetrahydro-naphthalene-2-ol; and
 1-(4'-Pyrrolidinoethoxyphenyl)-2-phenyl-6-hydroxy-1,2,3,4-tetrahydroisoquinoline.

By lesion progression is meant increased monocyte recruitment, growth with smooth muscle cell proliferation, migration, and matrix synthesis, and degeneration with cellular and extra cellular lipid accumulation.

By plaque stabilization is meant the inhibition of plaque passing through a phase in which the lipid core has grown and the fibrous cap is very thin and vulnerable to rupture due to an increase density of macrophages.

By chemokines is meant specific chemoattractant cytokine for monocytes belonging to the C-C (β) subfamily of chemokines including MIP-1α, MIP-1β, RANTES, MCP-1, MCP-2 and MCP-3 which are produced by endothelial cells, smooth muscle cells and macrophages found in the vessel wall.

By direct inhibition of chemokine expression is meant the inhibition of gene expression by interaction with a transcriptional element or factor that binds directly to the DNA, thus preventing the expression of that gene. Control of transcription is exercised at the level of initiation of mRNA synthesis.

By excessive monocyte recruitment is meant an inflammatory response leading to the accumulation of macrophages in the arterial wall due to the transendothelial migration of monocytes into the intimal space.

The term "treating", "treat" or "treatment" as used herein includes preventative (e.g., prophylactic) and palliative treatment

By halo is meant chloro, bromo, iodo, or fluoro.

By alkyl is meant straight chain or branched saturated hydrocarbon. Exemplary of such alkyl groups (assuming the designated length encompasses the particular example) are methyl, ethyl, propyl, isopropyl, butyl, sec-butyl, tertiary butyl, pentyl, isopentyl, hexyl and isohexyl.

By alkoxy is meant straight chain or branched saturated alkyl bonded through an oxy. Exemplary of such alkoxy groups (assuming the designated length encompasses the particular example) are methoxy, ethoxy, propoxy, isopropoxy, butoxy, isobutoxy, tertiary butoxy, pentoxy, isopentoxy, hexoxy and isohexoxy.

The expression "pharmaceutically-acceptable acid addition salt" refers to nontoxic anionic salts containing anions such as (but not limited to) chloride, bromide, iodide, sulfate, bisulfate, phosphate, acetate, maleate, fumarate, oxalate, lactate, tartrate, citrate, gluconate, methanesulfonate and 4-toluene-sulfonate.

The parenthetical negative or positive sign used herein in the nomenclature denotes the direction plane polarized light is rotated by the particular stereoisomer.

As used herein, the expressions "reaction-inert solvent" and "inert solvent" refers to a solvent which does not interact with starting materials, reagents, intermediates or products in a manner which adversely affects the yield of the desired product.

The chemist of ordinary skill will recognize that certain compounds of this invention will contain one or more atoms which may be in a particular stereochemical or geometric configuration, giving rise to stereoisomers and configurational isomers. All such isomers and mixtures thereof are included in this invention. Hydrates of the compounds of this invention are also included.

The chemist of ordinary skill will recognize that certain combinations of heteroatom-containing substituents listed in this invention define compounds which will be less stable under physiological conditions (e.g. those containing acetal or aминаl linkages). Accordingly, such compounds are less preferred.

Other features and advantages will be apparent from the specification and claims which describe the invention.

DETAILED DESCRIPTION OF THE INVENTION

The compounds of this invention inhibit the formation (e.g., progression) of atherosclerotic plaques and also aid in stabilizing plaques. In general, it is believed that several potential molecular targets may mediate this effect including pro inflammatory chemokines (e.g., MCP-1). MCP-1 is a potent chemoattractant factor for monocytes and macrophages. It is produced and secreted by endothelial cells, vascular smooth muscle cells and macrophages in response to inflammatory mediators such as IL-1 and oxidized lipids.

More particularly, it is believed that modification of low-density lipoprotein (LDL) by reactive oxygen species into oxidatively modified LDL (Ox-LDL) is central to the initiation of atherosclerosis. Areas of the vessel wall prone to plaque formation accumulate circulating LDL. Endothelial, smooth muscle and/or inflammatory cells then convert the LDL to Ox-LDL. Consequently, monocytes become engorged with Ox-LDL forming macrophage foam cells. The Ox-LDL and other risk factors activate genes within macrophages and other inflammatory cells to promote additional recruitment of inflammatory cells to the artery or vein vessel wall. The compounds of this invention are believed to limit the recruitment of inflammatory cells into the vessel wall which lead to atherosclerotic plaque progression by controlling the transcription of genes, such as Monocyte Chemoattractant Protein-1 (MCP-1), involved with the chemotaxis of monocytes at the level of mRNA synthesis. For example, as a result of our analysis of the lipid-fed ApoE KO mouse it is believed that the compounds of this invention lower the high levels of MCP-1 mRNA seen in the atherosclerotic lesions. The reduced levels of MCP-1 mRNA result in significant changes in monocyte migration resulting in the inhibition of atherogenic lesion progression.

The compounds of this invention also aid in stabilizing plaques. It is believed that early in the development of atherosclerotic plaques, all plaques pass through a phase in which the lipid core has grown and the fibrous cap is very thin and vulnerable to rupture. There is a great deal of evidence implicating macrophages (which secrete proteases and lipases) in the degradation of the fibrous cap. Davies et al (Br. Heart J. 1985; 53: 363-373) have described increased density of macrophages in ruptured plaques in comparison with stable plaques. Moreover the immediate site of plaque rupture or erosion is always marked by an inflammation process. The compounds of this invention also stabilize plaque by inhibiting monocyte (e.g., inflammatory cell) recruitment (e.g., monocyte infiltration) into the arterial wall leading to breakdown of the fibrous cap of the atherosclerotic lesion. This inhibition of monocyte recruitment occurs by directly inhibiting the expression of chemokines such as MCP-1 that results in excessive monocyte infiltration and foam cell formation in the arterial wall.

The above described effects (1. inhibiting atherogenic progression and 2. stabilizing plaque) occur through inhibiting the recruitment of inflammatory cells by directly controlling the expression of a gene. This direct controlling the expression of a gene is distinct from the inhibition of the peroxidation of lipids because it involves the direct controlling of chemokines at the DNA level rather than indirectly preventing gene expression by preventing lipid oxidation through the antioxidant properties of these compounds.

The estrogen agonist/antagonists of this invention are compounds as described in commonly assigned U.S. patent no. 5,552,412 the disclosure of which is hereby incorporated by reference.

The preparation of such compounds is also described in U.S. patent no. 5,552,412. Especially preferred compounds described therein and especially preferred compounds useful for this invention are:

Cis-6-(4-fluoro-phenyl)-5-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,6,7,8-tetrahydro-naphthalene-2-ol;
 (-)-Cis-6-phenyl-5-[4-(2-pyrrolidin-1-yl-ethoxy)-phenyl]-5,6,7,8-tetrahydro-naphthalene-2-ol;
 Cis-6-phenyl-5-[4-(2-pyrrolidin-1-yl-ethoxy)-phenyl]-5,6,7,8-tetrahydro-naphthalene-2-ol;
 Cis-1-[6'-pyrrolidinoethoxy-3'-pyridyl]-2-phenyl-6-hydroxy-1,2,3,4-tetrahydronaphthalene;
 1-(4'-Pyrrolidinoethoxyphenyl)-2-(4"-fluorophenyl)-6-hydroxy-1,2,3,4-tetrahydroisoquinoline;
 Cis-6-(4-hydroxyphenyl)-5-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,6,7,8-tetrahydro-naphthalene-2-ol; and
 1-(4'-Pyrrolidinoethoxyphenyl)-2-phenyl-6-hydroxy-1,2,3,4-tetrahydroisoquinoline.

Some of the preparation methods useful for making the compounds of this invention may require protection of remote functionality (i.e., primary amine, secondary amine, carboxyl). The need for such protection will vary depending on the nature of the remote functionality and the conditions of the preparation methods. The need for such protection is readily determined by one skilled in the art. The use of such protection/deprotection methods is also within the skill in the art. For a general description of protecting groups and their use, see T.W. Greene, Protective Groups in Organic Synthesis, John Wiley & Sons, New York, 1991. The starting materials and reagents for the compounds of this invention are also readily available or can be easily synthesized by those skilled in the art using conventional methods of organic synthesis.

Some of the compounds of this invention have asymmetric carbon atoms and therefore are enantiomers or diastereomers. Diastereomeric mixtures can be separated into their individual diastereomers on the basis of their physical chemical differences by methods known per se, for example, by chromatography and/or fractional crystallization.

Enantiomers can be separated by converting the enantiomeric mixture into a diastomeric mixture by reaction with an appropriate optically active compound (e.g., alcohol), separating the diastereomers and converting (e.g., hydrolyzing) the individual diastereomers to the corresponding pure enantiomers. All such isomers, including diastereomers, enantiomers and mixtures thereof are considered as part of this invention.

In addition, some of the compounds of this invention are basic, and they form a salt with a pharmaceutically acceptable anion. All such salts are within the scope of this invention and they can be prepared by conventional methods. For example, they can be prepared simply by contacting the acidic and basic entities, usually in a stoichiometric ratio, in either an aqueous, non-aqueous or partially aqueous medium, as appropriate. The salts are recovered either by filtration, by precipitation with a non-solvent followed by filtration, by evaporation of the solvent, or, in the case of aqueous solutions, by lyophilization, as appropriate.

In addition, when the compounds of this invention form hydrates or solvates they are also within the scope of the invention.

The methods of this invention are all adapted to therapeutic use by either inhibiting the recruitment of inflammatory cells by controlling gene expression or stabilizing plaque in mammals, particularly humans. Since these functions are closely related to the development of atherosclerosis and coronary heart disease related disorders, these methods prevent, arrest, regress or reverse atherosclerosis.

The utility of the compounds of the present invention as medical agents in the treatment of atherosclerosis in mammals (e.g., humans, particularly the female) is demonstrated by the activity of the compounds of this invention in conventional assays and the *in vivo* assays described below. Such assays also provide a means whereby the activities of the compounds of this invention can be compared between themselves and with the activities of other known compounds. The results of these comparisons are useful for determining dosage levels in mammals, including humans, for the treatment of such diseases.

The anti-atherosclerotic activity of these compounds can be determined by assessing the effect of these compounds, compared to placebo control, (administered subcutaneously, in ovariectomized female Apo E deficient mice fed a high fat diet) on the percent of the aortic surface covered by atherosclerotic lesions.

PROTOCOL

Animal Prep: Ovariectomized female, Apo E deficient mice are placed on a high fat diet. The animals are divided into control groups and test compound groups. The compound to be tested and placebo (contained in 60-day release subdermal pellets) are inserted beneath the skin at the back of the animal's neck with a trochar. The animals are redosed approximately 55 days after the initial dosing to allow the mice a total dosing period of approximately 90 days.

ANIMALS

Female, Apo E deficient transgenic mice

20 to 30 gram average weights

OVX at 25 days of age

Placed in individual isolation cages upon start of study

Dosed at 70 days of age for 90 days

Fed a Western-type diet containing 21% fat and 0.15% cholesterol (% by weight) (Harlan Teklad, Madison, Wisconsin, Cat# TD 88137 TEKLAD) for 3 months prior to sacrifice.

Sacrificed at 155 days of age

TIME RELEASE PELLETS

Time release pellets (60-day, 30mm) were obtained from Innovative Research of America (1-800-A21-8171) as follows:

Placebo: 5mg pellet (83ug/day) CAT #SC-111 obtained from Innovative Research of America (1-800-421-8171)

Test compound: pellet CAT # special order obtained from Innovative Research of America (1-800-421-8171)

Tissue Collection: At the end of the 90 day dosing period, the animals are fasted overnight prior to sacrifice. The animals are anesthetized and a whole blood sample is removed from each animal for analysis of plasma cholesterol and triglycerides. The mice are perfused *in situ* with PBS (via heart puncture in the left ventricle) for a short period or until the tissues are free of blood (perfusate is clear). The perfusate is switched to 4% cacodylate-buffered paraformaldehyde and the animal is perfusion fixed *in situ* for a short period. The uterus is removed and weighed. The heart and aorta (from the arch at the heart to just below the renal branch) are removed and transferred to separate vials containing

4% cacodylate-buffered paraformaldehyde. The tissues are post perfusion fixed for a few hours. The tissues are transferred to 30% gum sucrose and the sucrose is allowed to infiltrate the tissues for at least a day prior to sectioning.

Aorta: The exterior adventitia is removed from the aorta and the vessel is cut open by making a longitudinal cut along the side of the aorta starting at the arch and working down to the femoral branch. A second longitudinal cut is made on the other side of the aortic arch to split the vessel in half at this point. The amount of lesion is quantitated in the aortic vessel using for example, an OPTIMAS image analysis program ('OPTIMAS 4.1 software (Image Processing Solutions, Woburn, MA)). The aortas are stored in 10% buffered formalin.

Heart: The hearts are imbedded in OCT and cryostat sections of the aortic sinus and the aortic valve of the heart are made. 10µm sections are taken and every other section is saved on Vectabond coated slides. Each region of the aorta should encompass approx 3-4 slides w/ 4 sections per slide. The heart sections are stained for lipid with Oil Red O and the amount of lesion is quantitated in the aortic sinus and/or the aortic valve area using the OPTIMAS image analysis program.

Administration of the compounds of this invention can be via any method which delivers a compound of this invention systemically. These methods include oral routes, parenteral, intraduodenal routes, etc. Generally, the compounds of this invention are administered orally, but parenteral administration (e.g., intravenous, intramuscular, subcutaneous or intramedullary) may be utilized, for example, where oral administration is inappropriate for the instant target or where the patient is unable to ingest the drug. The compounds of this invention can be singly or co-administered simultaneously or sequentially in any order.

In any event the amount and timing of compound(s) administered will, of course, be dependent on the subject being treated, on the severity of the affliction, on the manner of administration and on the judgment of the prescribing physician. Thus, because of patient to patient variability, the dosages given below are a guideline and the physician may titrate doses of the drug to achieve the activity (i.e., antiatherosclerotic effect) that the physician considers appropriate for the individual patient. In considering the degree of activity desired, the physician must balance a variety of factors such as atherosclerotic starting level, age of the patient, as well as presence of other diseases (e.g., osteoporosis). For example, the administration of an estrogen agonist/antagonist can provide osteoporosis benefits particularly, for post-menopausal women. The following paragraphs provide preferred dosage ranges for the various compounds of this invention.

The amount of the compound of this invention to be used is determined by its activity as an antiatherosclerotic agent. This activity is determined by means of an individual compound's pharmacokinetics and its minimum maximal effective dose in inhibition of plaque formation and/or stabilization using a protocol as described above.

In general an effective dosage for the antiatherosclerotic activities of this invention, for the compounds of this invention, is in the range of 0.0001 to 200 mg/kg/day, preferably 0.001 to 10 mg/kg/day.

The compounds of the present invention are generally administered in the form of a pharmaceutical composition comprising at least one of the compounds of this invention together with a pharmaceutically acceptable vehicle or diluent. Thus, the compounds of this invention can be administered individually or together in any conventional oral, parenteral or transdermal dosage form.

For oral administration a pharmaceutical composition can take the form of solutions, suspensions, tablets, pills, capsules, powders, and the like. Tablets containing various excipients such as sodium citrate, calcium carbonate and calcium phosphate are employed along with various disintegrants such as starch and preferably potato or tapioca starch and certain complex silicates, together with binding agents such as polyvinylpyrrolidone, sucrose, gelatin and acacia. Additionally, lubricating agents such as magnesium stearate, sodium lauryl sulfate and talc are often very useful for tableting purposes. Solid compositions of a similar type are also employed as fillers in soft and hard-filled gelatin capsules; preferred materials in this connection also include lactose or milk sugar as well as high molecular weight polyethylene glycols. When aqueous suspensions and/or elixirs are desired for oral administration, the compounds of this invention can be combined with various sweetening agents, flavoring agents, coloring agents, emulsifying agents and/or suspending agents, as well as such diluents as water, ethanol, propylene glycol, glycerin and various like combinations thereof.

For purposes of parenteral administration, solutions in sesame or peanut oil or in aqueous propylene glycol can be employed, as well as sterile aqueous solutions of the corresponding water-soluble salts. Such aqueous solutions may be suitably buffered, if necessary, and the liquid diluent first rendered isotonic with sufficient saline or glucose. These aqueous solutions are especially suitable for intravenous, intramuscular, subcutaneous and intraperitoneal injection purposes. In this connection, the sterile aqueous media employed are all readily obtainable by standard techniques well-known to those skilled in the art.

For purposes of transdermal (e.g., topical) administration, dilute sterile, aqueous or partially aqueous solutions (usually in about 0.1% to 5% concentration), otherwise similar to the above parenteral solutions, are prepared.

Methods of preparing various pharmaceutical compositions with a certain amount of active ingredient are known, or will be apparent in light of this disclosure, to those skilled in this art. For examples of methods of preparing pharmaceutical compositions, see Remington's Pharmaceutical Sciences, Mack Publishing Company, Easton, Pa., 15th Edition.

(1975).

Pharmaceutical compositions according to the invention may contain 0.1%-95% of the compound(s) of this invention, preferably 1%-70%. In any event, the composition or formulation to be administered will contain a quantity of a compound(s) according to the invention in an amount effective to treat the disease/condition of the subject being treated.

EXAMPLE 1

This EXAMPLE compares the amount of atherosclerotic lesion found in ovariectomized female Apo E deficient mice fed a high fat diet and dosed subcutaneously with placebo, 17-beta estradiol, or {4-[2-(2-aza-bicyclo[2.2.1]hept-2-yl)-ethoxy]-phenyl}-[6-hydroxy-2-(4-hydroxy-phenyl)-benzo[b]thiophen-3-yl]-methanone, for 90 days.

Animals

Homozygous apolipoprotein (apo)E-deficient mice were bred in house. The mice had a mixed genetic background (129ola x C57B/6). Thirty-six mice were maintained in a 12 hour light/dark cycle room with free access to food and water. The mice were fed an adjusted calories "Western-type" diet (Harlan Teklad, Madison, Wisconsin, Cat# TD 88137, containing 21% fat and 0.15% cholesterol by weight). At weaning (age 28 days), female mice were bilaterally ovariectomized (OVX) or sham operated through a one centimeter dorsal incision. At 45 days of age, the mice were randomly assigned to one of three treatment groups and 60-day slow-release pellets (Innovative Research of America, Toledo, Ohio) were inserted interscapularly under anesthesia: 0.5 mg placebo, 6 µg per day of 17-beta estradiol, or 50 µg per day of {4-[2-(2-aza-bicyclo[2.2.1]hept-2-yl)-ethoxy]-phenyl}-[6-hydroxy-2-(4-hydroxy-phenyl)-benzo[b]thiophen-3-yl]-methanone. The mice were redosed after 55 days to allow for a total dosing period of 90 days.

Tissue Preparation

After an overnight fast, the mice were anesthetized with Ketamine/Xylazine/PLBS 1:1:2 (Miles Inc). Blood and uteri were then removed followed by in situ perfusion (80 mm²hg) with phosphate buffered saline (PBS) pH 7.4.

Sections were prepared for lipid staining and morphometric analysis as follows. Hearts were perfusion fixed in situ with 4% cacodylate-buffered paraformaldehyde. The heart and aorta were removed and fixed for an additional 2 to 3 hours in 4% cacodylate-buffered paraformaldehyde followed by infiltration with 30% gum sucrose (1% gum arabic + 30% sucrose in PBS) for 24 hours, 4°C. To determine cross-sectional lesion area, hearts were embedded in OCT imbedding medium (Optimal Cryostat Temperature Inc.) and cryostat sectioned at 10µ, -18°C. Every other section was mounted on Vectabond (Vector Laboratories, Inc., Burlingame, CA) coated slides. The area of the heart to be sectioned was divided into two separate regions commonly used for quantitating the degree of atherosclerotic lesions in mice, the aortic sinus and the aortic valve. When moving up from the base of the heart, the sinus began at the first appearance of the valve cusps dividing the lumen into three distinct regions. In this region, the aortic wall is bulging and irregular. The sinus region ends and the valve region begins when the valve cusps no longer divide the lumen and the wall appears more rounded and distinct. The valve began at the end of the sinus and continued until the valve cusps were no longer apparent and the wall was well rounded (approximately 280 µm). Sections were stained for lipid with Oil red O (0.5% in propylene glycol, Polyscientific, BayShore, NY) and counterstained with Gill's III Hematoxylin (Sigma).

Lesion Analysis

Each section of the aortic sinus and the aortic valve was evaluated for Oil red O staining area by capturing images directly from a camera attached to a Leitz Laborlux S (Leica) light microscope and displaying them on a Trinitron RGB monitor. Image analysis was determined using 'OPTIMAS 4.1 software (Image Processing Solutions, Woburn, MA). The outer and inner perimeters of the aortic wall in cross sections were delineated and thresholds were set to distinguish between normal (hematoxylin stained) and diseased (Oil red O stained) tissue. The results were expressed as the average lesion size per section or as the percent of the total cross sectional vessel wall area (normal + diseased area/section, excluding the lumen) stained with Oil red O. For each animal, the average of 12 to 16 sections was determined and data are expressed as lesion size or mean percent lesion area.

The percent of the aortic surface covered by lesions was determined using an en face preparation. Aortas infiltrated with gum sucrose as described above were cleaned of adventitia and a longitudinal cut was made from the arch down toward the femoral branch. A second longitudinal cut was made between the coronary and carotid arteries in the aortic arch and the aorta was laid open on a piece of polystyrene. Each aorta was evaluated for lesion area by direct image capture from a CCD camera attached to a copy stand and displayed on a Trinitron monitor. The lesion area was determined in unstained tissue using 'OPTIMAS 4.1 image analysis. Areas of atherosclerotic plaques in aortas cleaned

of adventitia appear as yellowish-white areas. This area was quantitated by manually setting thresholds for shades of black (background), gray (normal tissue) and white (lesion area).

Plasma lipids

Total plasma cholesterol and triglycerides were measured using colorimetric methods with commercially available kits (Wako and Boehringer-Mannheim).

Statistical Analysis

Analysis of variance (ANOVA) was used to test for statistically significant differences between the groups with regard, treatment, serum lipids and lesion size. Fisher's F test was used to determine significant differences among means.

Results

The results of the Example are detailed in the following Table. The Example demonstrates the validity of the protocol by demonstrating the reduction in atherosclerotic lesion size for the estrogen agonist {4-[2-(2-aza-bicyclo[2.2.1]hept-2-yl)-ethoxy]-phenyl}-[6-hydroxy-2-(4-hydroxy-phenyl)-benzo[b]thiophen-3-yl]-methanone. Importantly, this occurred without a reduction in cholesterol as the cholesterol lowering activity of the estrogen agonist was not observed in this experiment, either because the compound was administered subcutaneously rather than orally or mice are non-responsive to estrogen-like compounds with regard to lipid effects.

TABLE

{4-[2-(2-Aza-bicyclo[2.2.1]hept-2-yl)-ethoxy]-phenyl}-[6-hydroxy-2-(4-hydroxy phenyl)-benzo[b]thiophen-3-yl]-methanone Reduces Lesion Size in OVX apoE- Deficient Mice Without Affecting Plasma Lipids or Uterine Weight					
Group	N	Total Cholesterol (mg/dl)	Triglycerides (mg/dl)	Uterine WT (gm)	Aortic Valve Lesion area (%)
Placebo	15	929±315	96±24	37±39	33.4±11.2
17-beta estradiol (6 µg/d)	8	641±172*	53±24*	165±105*	18.9±6.2*
X (50 µg/d)	10	820±134	91±55	35±15	21.2±6*

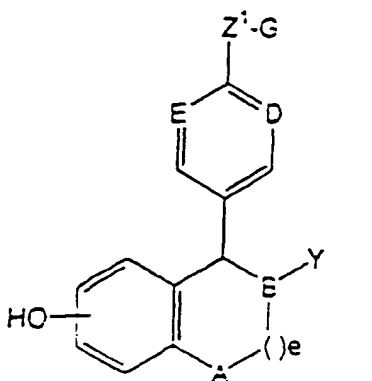
* Significant difference from placebo (P is less than 0.05)

X is {4-[2-(2-aza-bicyclo[2.2.1]hept-2-yl)-ethoxy]-phenyl}-[6-hydroxy-2-(4-hydroxyphenyl)-benzo[b]thiophen-3-yl]-methanone

It should be understood that the invention is not limited to the particular embodiments described herein, but that various changes and modifications may be made without departing from the spirit and scope of this novel concept as defined by the following claims.

Claims

1. The use of a compound of the formula (I), or of an optical or geometric isomer thereof; or of a non-toxic pharmacologically acceptable acid addition salt, N-oxide, ester or quaternary ammonium salt thereof, for the manufacture of a medicament for treating atherosclerosis, independent of lipid lowering:-



wherein:

A is selected from CH_2 and NR ;

B, D and E are independently selected from CH and N;

Y is

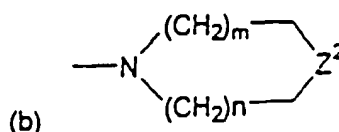
- (a) phenyl, optionally substituted with 1-3 substituents independently selected from R^4 ;
- (b) naphthyl, optionally substituted with 1-3 substituents independently selected from R^4 ;
- (c) C_3 - C_8 cycloalkyl, optionally substituted with 1-2 substituents independently selected from R^4 ;
- (d) C_3 - C_8 cycloalkenyl, optionally substituted with 1-2 substituents independently selected from R^4 ;
- (e) a five membered heterocycle containing up to two heteroatoms selected from the group consisting of $-\text{O}-$, $-\text{NR}^2-$ and $-\text{S}(\text{O})_n-$, optionally substituted with 1-3 substituents independently selected from R^4 ;
- (f) a six membered heterocycle containing up to two heteroatoms selected from the group consisting of $-\text{O}-$, NR^2- and $-\text{S}(\text{O})_n-$ optionally substituted with 1-3 substituents independently selected from R^4 ; or
- (g) a bicyclic ring system consisting of a five or six membered heterocyclic ring fused to a phenyl ring, said heterocyclic ring containing up to two heteroatoms selected from the group consisting of $-\text{O}-$, $-\text{NR}^2-$ and $-\text{S}(\text{O})_n-$, optionally substituted with 1-3 substituents independently selected from R^4 ;

Z^1 is

- (a) $-(\text{CH}_2)_p \text{W}(\text{CH}_2)_q-$;
- (b) $-\text{O}(\text{CH}_2)_p \text{CR}^5\text{R}^6-$;
- (c) $-\text{O}(\text{CH}_2)_p \text{W}(\text{CH}_2)_q-$;
- (d) $-\text{OCHR}^2\text{CHR}^3-$; or
- (e) $-\text{SCHR}^2\text{CHR}^3-$;

G is

- (a) $-\text{NR}^7\text{R}^8$;

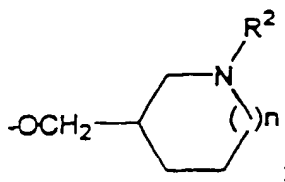


wherein n is 0, 1 or 2; m is 1, 2 or 3; Z^2 is $-\text{NH}-$, $-\text{O}-$, $-\text{S}-$, or $-\text{CH}_2-$; optionally fused on adjacent carbon atoms with one or two phenyl rings and, optionally independently substituted on carbon with one to three substituents and, optionally, independently on nitrogen with a chemically suitable substituent selected from R^4 ; or

- (c) a bicyclic amine containing five to twelve carbon atoms, either bridged or fused and optionally substi-

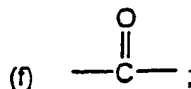
tuted with 1-3 substituents independently selected from R^4 ; or

Z^1 and G in combination may be

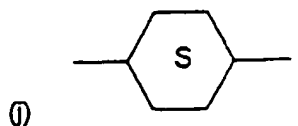


W is

- 15
- (a) $-\text{CH}_2-$;
 (b) $-\text{CH}=\text{CH}-$;
 (c) $-\text{O}-$;
 (d) $-\text{NR}^2-$;
 (e) $-\text{S}(\text{O})_n-$;
- 20



- (g) $-\text{CR}^2(\text{OH})-$;
 (h) $-\text{CONR}^2-$;
 (i) $-\text{NR}^2\text{CO}-$;
- 30



- or
 (k) $-\text{C}=\text{C}-$;

R is hydrogen or C_1 - C_6 alkyl;
 R^2 and R^3 are independently

40

- (a) hydrogen; or
 (b) C_1 - C_4 alkyl;

R^4 is

45

- (a) hydrogen;
 (b) halogen;
 (c) C_1 - C_6 alkyl;
 (d) C_1 - C_4 alkoxy;
 (e) C_1 - C_4 acyloxy;
 (f) C_1 - C_4 alkylthio;
 (g) C_1 - C_4 alkylsulfinyl;
 (h) C_1 - C_4 alkylsulfonyl;
 (i) hydroxy (C_1 - C_4)alkyl;
 (j) aryl (C_1 - C_4)alkyl;
 (k) $-\text{CO}_2\text{H}$;
 (l) $-\text{CN}$;
- 50
- 55

- (m) -CONHOR;
 (n) -SO₂NHR;
 (o) -NH₂;
 (p) C₁-C₄ alkylamino;
 (q) C₁-C₄ dialkylamino;
 (r) -NHSO₂R;
 (s) -NO₂;
 (t) -aryl; or
 (u) -OH;

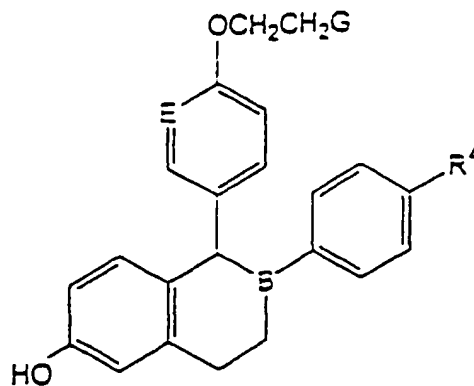
R⁵ and R⁶ are independently C₁-C₈ alkyl or together form a C₃-C₁₀ carbocyclic ring;
 R⁷ and R⁸ are independently

- (a) phenyl;
 (b) a C₃-C₁₀ carbocyclic ring, saturated or unsaturated;
 (c) a C₃-C₁₀ heterocyclic ring containing up to two heteroatoms, selected from -O-, -N- and -S-;
 (d) H;
 (e) C₁-C₆ alkyl; or
 (f) form a 3 to 8 membered nitrogen containing ring with R⁵ or R⁶;

R⁷ and R⁸ in either linear or ring form may optionally be substituted with up to three substituents independently selected from C₁-C₆ alkyl, halogen, alkoxy, hydroxy and carboxy;

a ring formed by R⁷ and R⁸ may be optionally fused to a phenyl ring;
 e is 0, 1 or 2;
 m is 1, 2 or 3;
 n is 0, or 2;
 p is 0, 1, 2 or 3;
 q is 0, 1, 2 or 3.

2. The use of a compound of the formula (I) as defined in claim 1, or of an optical or geometric isomer thereof, or of a non-toxic pharmacologically acceptable acid addition salt, N-oxide, ester or quaternary ammonium salt thereof, for the manufacture of a medicament for inhibiting progression of an atherogenic lesion or for stabilising plaque.
3. The use of a compound of the formula (I) as defined in claim 1, or of an optical or geometric isomer thereof, or of a non-toxic pharmacologically acceptable acid addition salt, N-oxide, ester or quaternary ammonium salt thereof, for the manufacture of a medicament for inhibiting chemokine expression leading to excessive inflammatory cell recruitment or for inhibiting lipid peroxidation.
4. A use according to any one of the preceding claims wherein the compound of the formula (I) has the formula:-



wherein G is



R^4 is H, OH, F, or Cl; and B and E are independently selected from CH and N.

5. A use according to any one of claims 1 to 3 wherein the formula I compound is

Cis-6-(4-fluoro-phenyl)-5-[4-(2-piperidin-1-yl-ethoxy)-phenyl]-5,6,7,8-tetrahydro-naphthalene-2-ol;
 (-)-Cis-6-phenyl-5-[4-(2-pyrrolidin-1-yl-ethoxy)-phenyl]-5,6,7,8-tetrahydro-naphthalene-2-ol;
 Cis-6-phenyl-5-[4-(2-pyrrolidin-1-yl-ethoxy)-phenyl]-5,6,7,8-tetrahydro-naphthalene-2-ol;
 Cis-1-[6'-pyrrolidinoethoxy-3'-pyridyl]-2-phenyl-6-hydroxy-1,2,3,4-tetrahydronaphthalene;
 1-(4'-Pyrrolidinoethoxyphenyl)-2-(4"-fluorophenyl)-6-hydroxy-1,2,3,4-tetrahydroisoquinoline;
 Cis-6-(4-hydroxyphenyl)-5-[4-(2-pipendin-1-yl-ethoxy)-phenyl]-5,6,7,8-tetrahydro-naphthalene-2-ol; or
 1-(4'-Pyrrolidinoethoxyphenyl)-2-phenyl-6-hydroxy-1,2,3,4-tetrahydroisoquinoline.